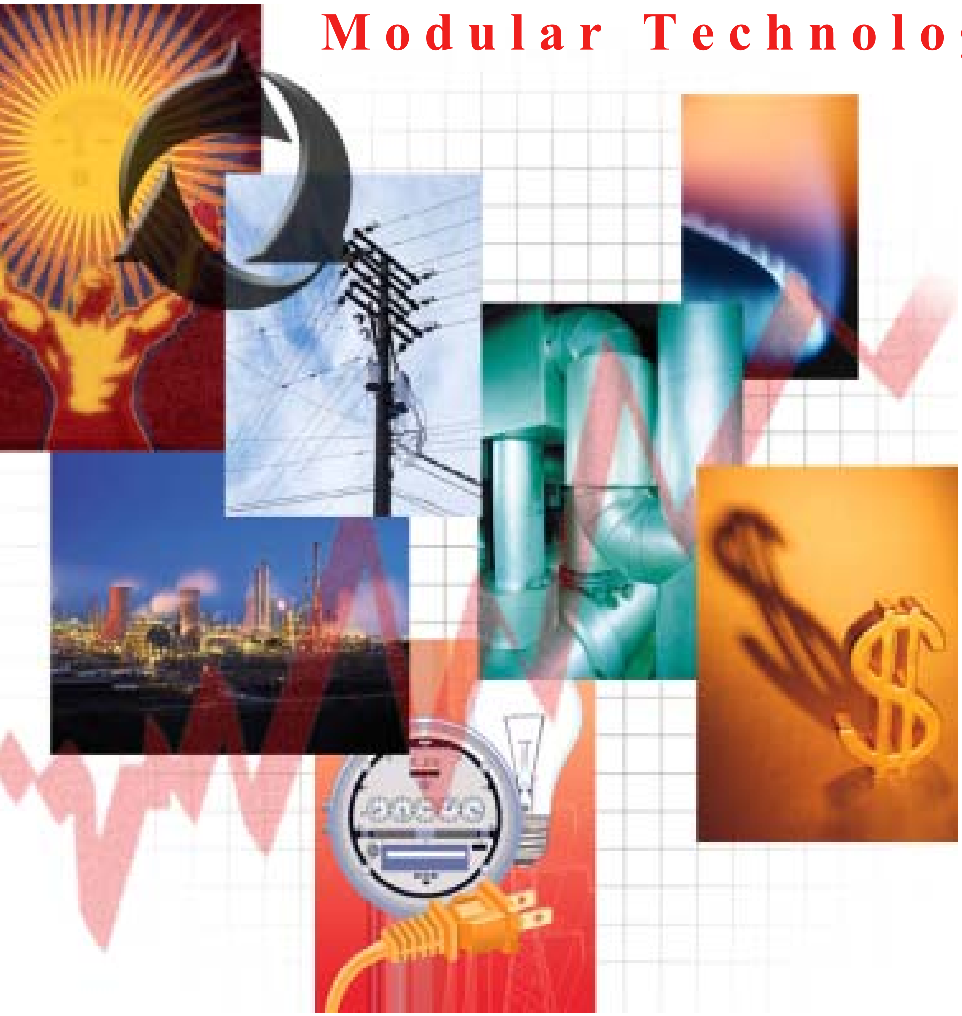
Modular Technology for Large IES Systems



U.S. Department of Energy

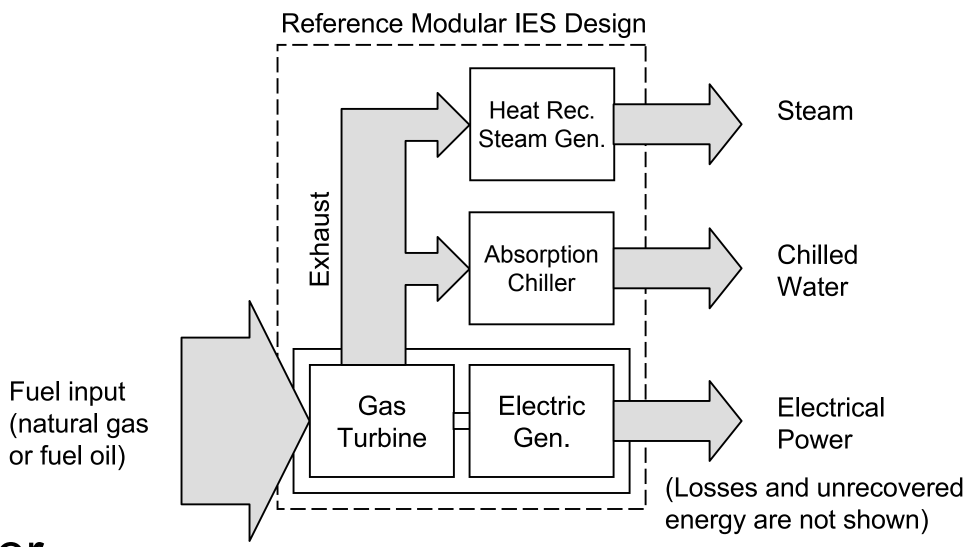
DER Peer Review

December 2-4, 2003

Project Overview

Objective:

Develop packaging technologies for large (2 to 5 MW) IES systems, and field test a prototype design.



Major equipment:

- Gas turbine generator
- Heat recovery steam generator
- Waste heat fired absorption chiller

Key Goals:

- Develop "reference" CAD-based modular IES system designs
- Develop a supervisory control system with on-line optimization
- Develop an exhaust-driven absorption chiller (1000 ton cooling capacity)
- Install and monitor the performance of a prototype modular IES system

Project Motivations

Address key technology needs for IES Systems

IES Technology Need	Solution	Technical Approach
1. Increase reuse of IES system design data	Reference designs to improve economics, and simplify installation	Use industry standards for CAD, and develop templates for performance analysis
2. Improve ability to adapt to changing loads and utility rates	Supervisory control system with on-line optimization	Apply on-line optimization for improved response to varying operating conditions and energy costs
3. Increase energy efficiency	Exhaust-driven Absorption Chiller	Apply proven 2-stage absorption technology, with the addition of an exhaust-driven generator

Project Team

Honeywell Labs

- **Honeywell Labs** — www.htc.honeywell.com
- **I.C. Thomasson** — www.icthomasson.com
- **Chelsea Group** — www.chelsea-grp.com
- **Honeywell Energy Services Team Ft. Bragg, NC** — Honeywell Energy Services
- **Broad USA** — www.broadusa.com

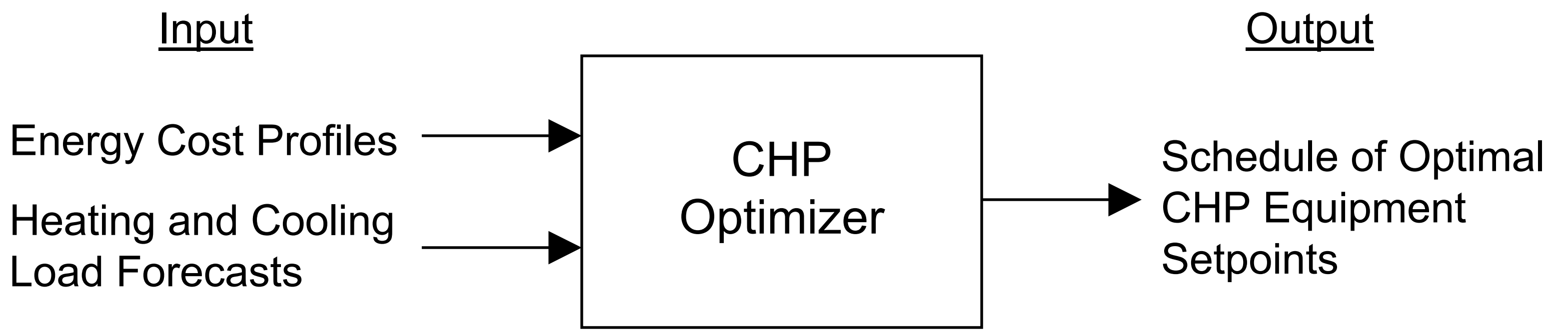
Key R&D Areas

- **Reference Designs for modular IES systems** (to promote the technology)
- **On-line Optimization** (makes best use of turbine exhaust, gas, oil, and electric energy sources)
- **Application of exhaust-driven cooling** (applied with electric chillers for cost and energy efficiency)

Project Tasks

Task	Activities
Packaged System Concept	Requirements definition Conceptual design
Prototype Development	Develop reference designs Design and manufacture 1000 ton absorption chiller Develop supervisory control system with on-line optimization Install prototype system at Ft. Bragg, NC
Field Monitoring / Reporting	Monitor performance at Ft. Bragg Reviews and reports

Optimization and Supervisory Control



- Objective Function Formulation
- Equipment Performance Models
- Configuration Data
- Equipment availability and other constraint data

Ft. Bragg Site Overview

82nd Central Heating Plant:

- Largest central plant on the base, a good application for IES
- Serves barracks and other buildings
- Energy Services Performance Contract project by Honeywell Energy Services Team for U.S. Army
- On site power generation and energy recovery to replace poorly performing steam boilers
- 5 MW gas turbine and HRSG are provided by Honeywell Energy Services Team as cost sharing to this DOE IES project
- Showcase CHP project for FEMP, administered by FEMP program office at ORNL

Project Milestones

Work Completed in FY03:

- Design and manufacturing of the exhaust-driven 1000 ton absorption chiller
- IES design work for the Ft. Bragg site
- Preliminary installation work at Ft. Bragg. Notice-to-proceed was received from the U.S. Army
- Conceptual design and functional requirements for the control and on-line optimization software
- Building interface requirement guidelines defined and posted to bchp.org website

Project Milestones

Work Planned for FY04:

- Complete the IES equipment installation at Ft. Bragg, and commission the system (April 2004)
- Complete the development of the supervisory control and optimization software, and install at Ft. Bragg (April 2004)
- Monitor the operation of the Ft. Bragg IES system, and measure its performance
- Complete the development of the IES Reference Designs
- Prepare a final project report

Project Challenges

Subject	Challenge	Strategy
Reference Designs	Ability to share and disseminate the design data	Utilize a defacto standard (AutoCAD), this can also be imported into most other CAD systems
	Ability of practitioners to re-use design data	Develop templates for the reference designs, and a database of example projects
	Ability to incorporate future improvements in equipment performance	Use heat rate and other performance parameters to characterize the equipment for design and analysis
Control and Optimization	Ability to apply to different IES equipment	Develop generalized equipment models that can be tailored to each site application
	Application of a variety of electric utility rate structures	Interface to utility company websites to acquire energy price data, or use a commercial subscription service to obtain energy price data
Absorption Chiller	Ability to control exhaust flow based on standard chiller requirement	Integration of standard HRSG-type exhaust flow control methods with absorber specific controls.

Project Risks

Subject	Risk	Assessment	Remarks
Reference Designs	Reference designs may not apply to a particular site	low risk	Some sites will have unusual requirements, but most sites should be capable of applying a reference design
Control and Optimization	Electric rates may not be available in the subscription service	medium risk	Can hard code the specific rate into the controller, if needed
	Electric and thermal load data may not be available	medium risk	Can manually construct a load history for commissioning, then update on-line
Absorption Chiller	Application of exhaust control to standard absorption technology	medium risk	Site specific controls and logic to be incorporated to integrate the chiller operations with control demands

Impacts on DOE IES Program

Expected Results of this Project:

- Use of modular IES reference designs will facilitate wider application of these systems in the buildings sector
- Optimizing the operation of modular IES systems will maximize economic benefits to building owners

Impact on IES Goals:

- Improved energy efficiency for building owners
- Improved energy delivery (on site power generation reduces burden on transmission networks)

Project Summary

Key Project Benefits :

- Improves economics for Modular IES, thru use of reference designs and optimized operation
- Promotes wider use of Modular IES to improve energy efficiency
- Contributes to goals of National Energy Policy:
  - Performance based energy efficiency improvement using public-private partnership
  - Supports Combined Heating, Cooling, and Power

Technical Data

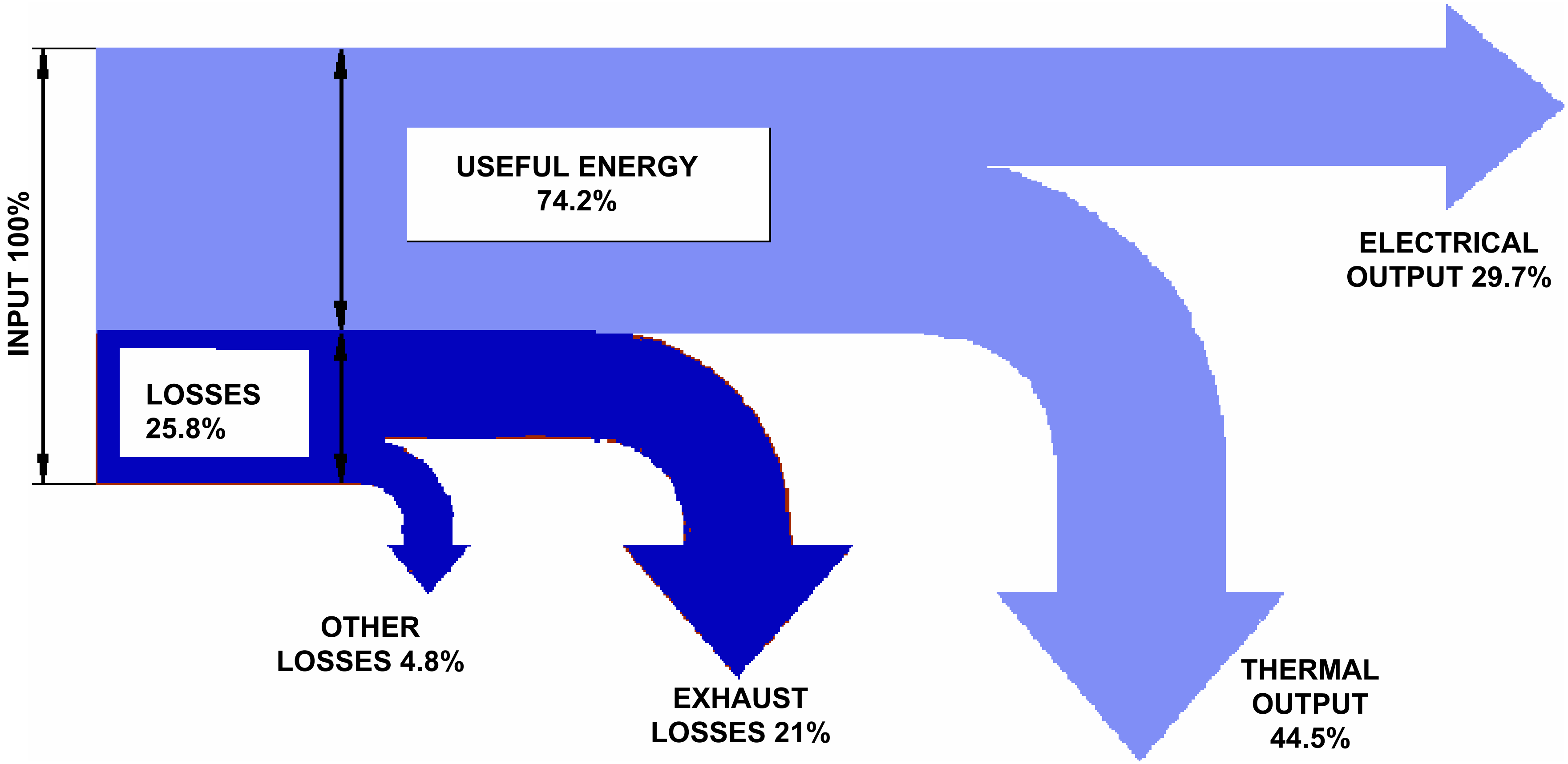
Additional technical information can be found at :
ftp://ftp.htc.honeywell.com/incoming/index_DER.html

Absorption Chiller Development

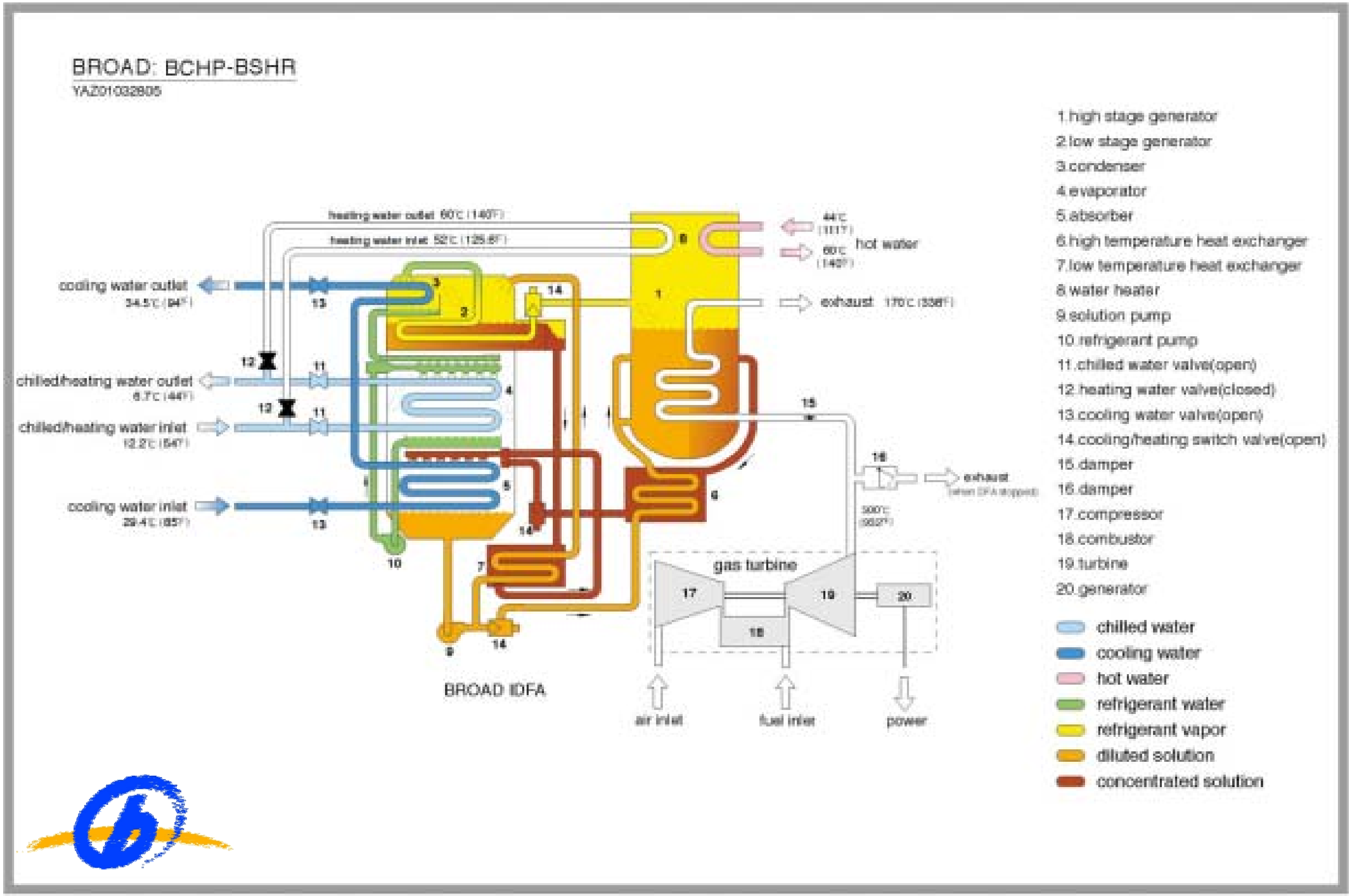
BroadUSA

Absorption Chiller

Concept Typical System Efficiency



Equipment Schematic



Two-Stage Exhaust-Fired Absorber

- Exhaust from the Gas turbine is taken directly into the Absorber.
- Absorber design is similar to standard commercial product.
- Design, development and construction focused on High Stage Generator and controls.

Project Specific Considerations

- Approx. 40% of total exhaust is taken to the absorber at full load.

- Concept combines criteria for HRSG design and LiBr Generator.

- Chiller is designed for various turbine inlet air temp (50^0F-110^0F) to produce 992 TR continuously.

Concept Design

– Primary control of Chiller is leaving chilled water temperature.

– Exhaust flow to the machine is controlled by inverter on exhaust ID fan.

– Safety shut down incorporates an inlet damper.

– All other machine safeties and control remain same as standard machine.

Reference Design Development

I.C. Thomasson

Reference Design Overview

Key Principles:

- Identify the key modules (e.g. turbine, chiller, etc.), and make baseline (example) equipment selections
- Design the interconnections and modularize the auxiliary equipment
- Document the resulting reference designs, so they can be re-used by owners and engineers in many different site applications

Reference Design Content

Element	Description
Overview Document	Written Overview Schematics and block diagrams High-level performance specs List of major equipment Brief sequence of operations
CAD Drawings	Cover sheet, notes, symbols, nomenclature General equipment arrangement P&ID, Mechanical, and Electrical drawings
Example Site-specific Details	(taken from Ft. Bragg project)
Mfr. Spec. Data	Spec. data for all equipment (may reference mfr. literature or web sites)

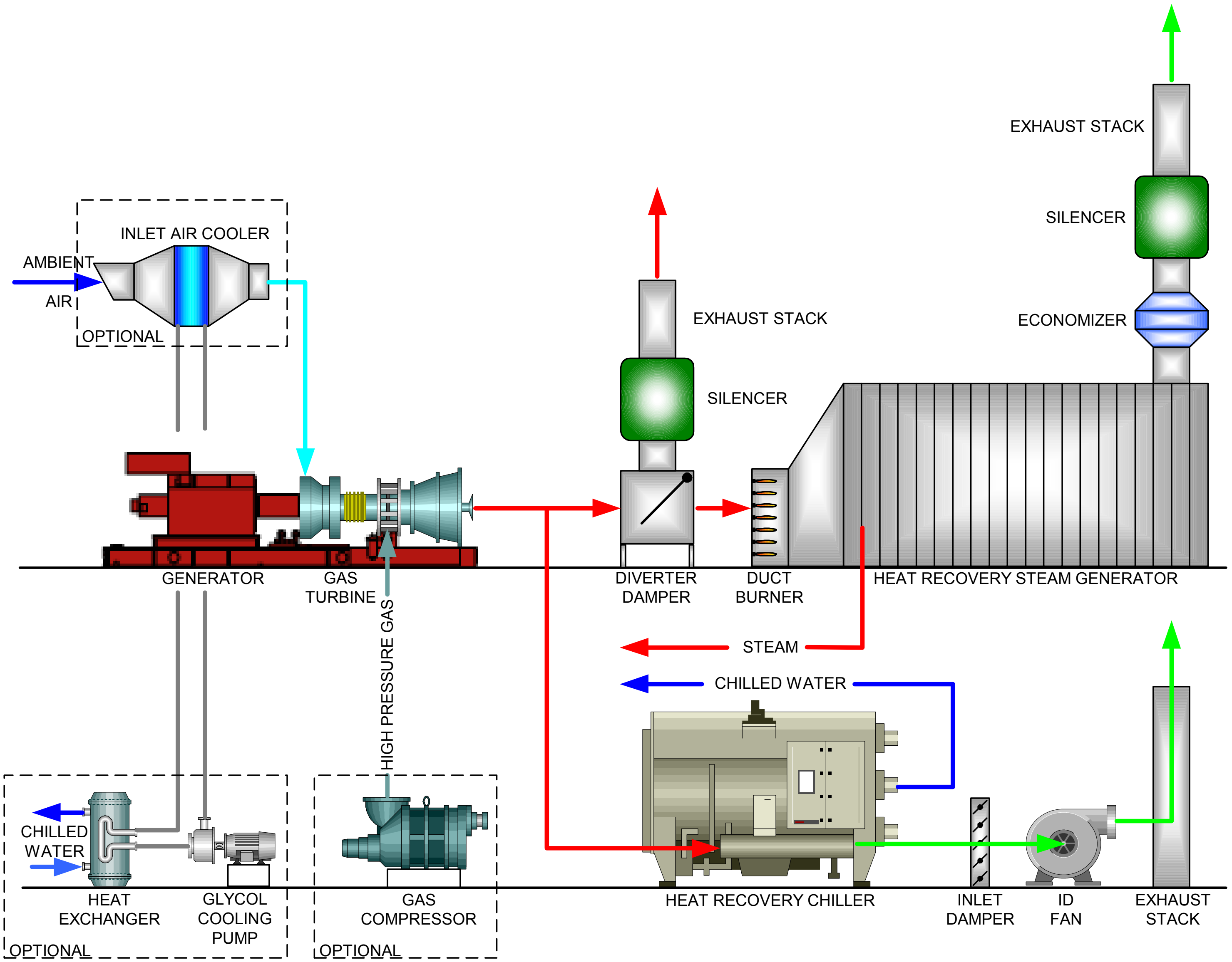
Reference Designs

CHILLED WATER PRODUCTION

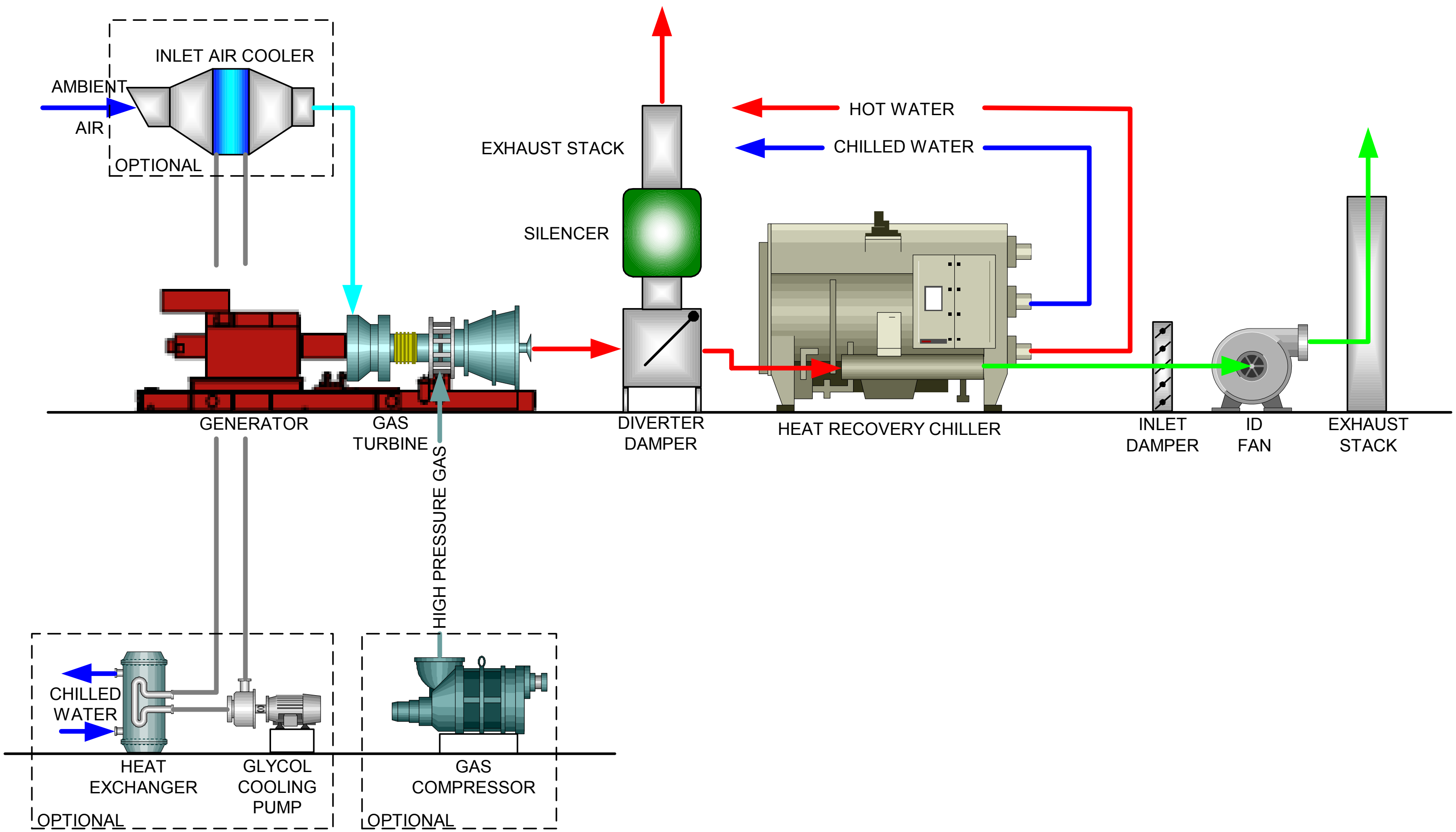
UNFIRED STEAM PRODUCTION

Reference Design	Turbine Generator	HRSG fired/unfired (kpph)	Chiller (tons)	Chiller/Heater (cooling tons/ heating MBH)	Heat Recovery (%cooling/ %heating)
R1	5.7MW	80/28	1,000	---	40/60 to 0/100
R2	5.2MW	---	---	2,500 / 23,750	100/0 to 0/100
R3	4.4MW	80/23	2,000	---	100/0 to 0/100
R4	4.4MW	---	---	2,000 / 19,000	100/0 to 0/100
R5	3.3MW	70/17	1,500	---	100/0 to 0/100
R6	3.3MW	---	---	1,500 / 14,250	100/0 to 0/100
R7	1.5MW	30/8	500	---	100/0 to 0/100
R8	1.5MW	---	---	500 / 4,750	100/0 to 0/100

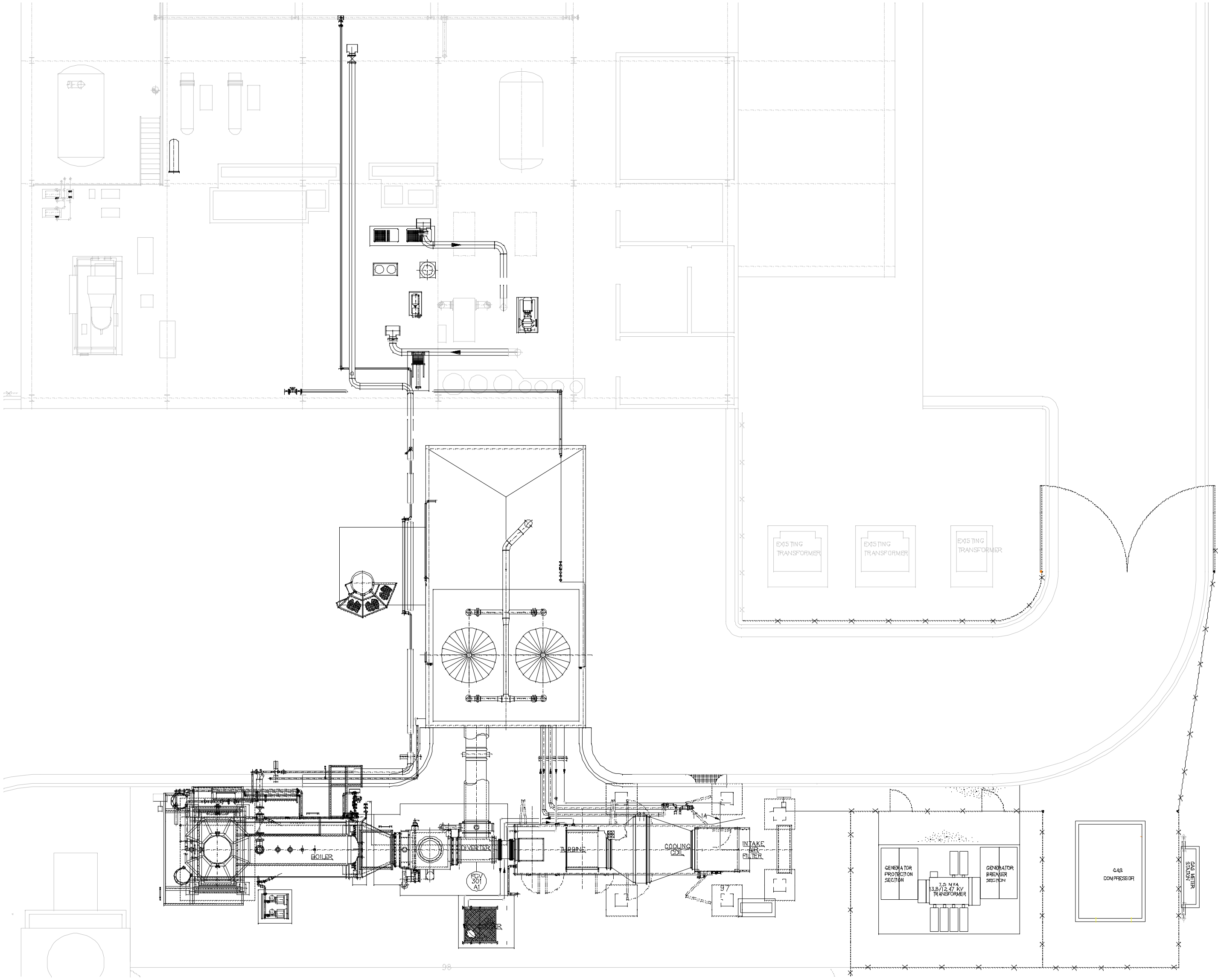
CHP Reference Design Equipment (R1,3,5,7)



CHP Reference Design Equipment (R2,4,6,8)



Example General Arrangement



Example P&ID (partial)